Senior Service College FELLOWSHIP PROJECT

FROM SERVICE OPERATIONAL HEADQUARTERS TO JOINT TASK FORCE CAPABLE HEADQUARTERS: AN ORGANIZATIONAL TRANSITION MODEL

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USAWC CLASS OF 2007

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REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	**2. REPORT TYPE**	**3. DATES COVERED** *(From - To)*
27-04-2007	Civilian Research Paper	

4. TITLE AND SUBTITLE

From Service Operational Headquarters to Joint Task Force Capable Headquarters: An Organizational Transition Model

5a. CONTRACT NUMBER

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)

LTC Mark C. Strong, ARNG

5d. PROJECT NUMBER

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

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10. SPONSOR/MONITOR'S ACRONYM(S)

11. SPONSOR/MONITOR'S REPORT NUMBER(S)

12. DISTRIBUTION / AVAILABILITY STATEMENT

DISTRIBUTION A: Unlimited

13. SUPPLEMENTARY NOTES

The views of the academic research paper are those of the author and do not reflect the official policy of the U.S. Government, the Department of Defense, or any of its agencies.

14. ABSTRACT

The six years of near continuous operations in the South West Asia, coupled with potential global contingencies, have maintained operational requirements for joint command and control, specifically Joint Task Force (JTF) capable headquarters, in excess of available manned, trained and equipped Service headquarters. The Defense Department, through the 2006 Quadrennial Defense Review, "directed the transformation of designated Service operational headquarters into effective and scalable Joint Task Force headquarters capable of immediately commanding and controlling integrated joint operations as part of Unified Action. This research document looks at the organizational design requirements for Service headquarters to operate as JTF headquarters. Specifically, the study develops three alternatives to organize a JTF capable headquarters and uses the Analytic Hierarchy Process as a method to evaluate competing headquarters design alternatives. Finally, the research investigates the use of Multi-Agent Systems modeling as an efficient tool to analyze JTF staff sections to solve problems that require self-organization and adaptation.

15. SUBJECT TERMS

16. SECURITY CLASSIFICATION OF:			**17. LIMITATION OF ABSTRACT**	**18. NUMBER OF PAGES**	**19a. NAME OF RESPONSIBLE PERSON**
a. REPORT	**b. ABSTRACT**	**c. THIS PAGE**			**19b. TELEPHONE NUMBER** *(include area code)*
UNCLASSIFIED	UNCLASSIFED	UNCLASSIFED	UNCLASSIFIED	65	

USAWC CIVILIAN RESEARCH PROJECT

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ABSTRACT

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TITLE: From Service Operational Headquarters to Joint Task Force Capable Headquarters: an Organizational Transition Model

FORMAT: Civilian Research Project

DATE: 27 April 2007 WORD COUNT: 11636 PAGES: 65

CLASSIFICATION: Unclassified

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ACKNOWLEDGEMENT

I wish to express my gratitude to my project advisors, Dr. Michael L. McGinnis (Old Dominion University) and Dr. John A. Bonin (U.S. Army War College) for their assistance in this research project. Their instructive reviews of the research project made it more understandable and complete by correcting errors and omissions.

Special thanks to COL Tim Keppler (U.S. Army TRADOC LNO to USJFCOM) for helping me understand the numerous issues that are involved in organizing a JTF capable Service headquarters.

Thanks to great soldiers and civilians at the Combined Arms Doctrine Directorate, Fort Leavenworth, Kansas for their insights into the ongoing modular design work for the U.S Army Division and Corps headquarters.

Thanks also to CDR Marc Peot and CAPT Bart Moore (2nd FLT HQs) for taking their time to explain the U.S. Navy's initiatives to build a JTF capable Fleet Headquarters.

This research document is dedicated to my family: my wife Donita and my son Tyler for their love and unending support.

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Introduction

Despite years of Department of Defense (DoD) transformation initiatives, the United States Armed Forces lack the necessary joint command and control headquarters capabilities to support current operations and potential contingencies across the globe. The protracted operations for the Global War on Terrorism continue to pressure the DoD and Services as they balance the requirements of a long war against the forces available to meet these requirements. The six years of near continuous operations in the South West Asia, coupled with potential global contingencies, have maintained operational requirements for joint command and control, specifically Joint Task Force (JTF) capable headquarters, in excess of available manned, trained and equipped Service headquarters. This shortfall reflects an ever decreasing ability to maintain a rotational force of available joint headquarters. Particularly stretched are the U.S. Army and U.S. Marine Corps (USMC). These two services, including active and reserve forces, are conducting the vast majority of current operations in the Middle East with a decreasing capacity to maintain a rotation of personnel and units. To further complicate the Army and USMC manpower issues, the DoD continues to move forward with the initiative to increase joint command and control headquarters capabilities across all six Unified Commands. DoD, through the 2006 Quadrennial Defense Review (QDR 06), "directed the transformation of designated Service operational headquarters into effective and scalable Joint Task Force headquarters capable of immediately commanding and controlling integrated joint operations as part of Unified Action."[1] The QDR 06 requirement transforms all Service 3-star and selected Service 2-star headquarters into JTF capable Service headquarters to support ongoing rotational and potential contingencies for the combatant commanders.

This research report focuses on the transformational problem to convert existing Service headquarters into JTF capable headquarters and investigates computer based modeling and

simulation as a method to solve the transformation problem. The research looked at the evolution of joint headquarters requirements directed by the DoD, alternatives to reorganize Army, Marine Corps, Navy and Air Force 3-star Service headquarters and capabilities, and the application of modeling and simulation as a method to solve the transformation problem. Chapter 1 addresses the problem statement with associated assumptions and research goals. Chapter 2 discusses a series of DoD and NATO initiatives that have been instrumental in the evolution of joint headquarters. Chapter 3 identifies three alternatives to reorganize Service headquarters as JTF headquarters as well as presents the Analytic Hierarchy Process as a method to evaluate competing headquarters design alternatives. Chapter 4 investigates the use of Multi-Agent Systems modeling to study the organizational framework of the JTF headquarters. The final chapter summarizes conclusions and outlines the future work necessary to accomplish the QDR 06 directives.

CHAPTER 1: PROBLEM FORMULATION

> "Today's deployable JTF HQ [headquarters] is an ad hoc organization, most often formed around a core Service component operational HQ with additional individual augmentees, just-in-time training (if time permits), and communications systems equipment provided in a piecemeal fashion."[2]
>
> -- USJFCOM J-3

1.1 General Problem

As noted above by the Joint Forces Command J-3, the ad hoc nature and formation of JTF headquarters leaves much to be desired from the combatant command perspective. Requisite joint headquarters capabilities come from headquarters with fulltime joint manning that is trained and certified for a specific JTF mission. Historically, this is accomplished through an application of the Joint Manning Document to provide the mission specific augmentation, including manpower and associated equipment, to a designated JTF headquarters. In 2004, the Joint Manpower Exchange Program began placing military personnel in joint billets outside the traditional Services to improve inter-service communication and information sharing. This program "provides component commanders a no-cost increase in joint capability by providing a one-for-one exchange of selected staff functional billets. While the Joint Manpower Exchange Program has no impact on overall military personnel end strength, organic joint expertise is achieved by exposing field grade officers and senior enlisted personnel to operations in a working joint environment".[3] The Joint Manpower Exchange Program provides increased joint manning to 3-star Service headquarters there by improving joint contingency planning, but does not provide the headquarters with "go to war" JTF capabilities. The Joint Manning Document provides the requisite joint personnel as determined by the Commander Joint Task Force, to command and control joint operations as part of Unified Action.

In 2006, the Defense Department published the Quadrennial Defense Review requiring the military services to develop JTF capable Service headquarters. The 2006 Quadrennial Defense Review conducted a comprehensive review of national defense strategy, force

structure, force modernization plans, infrastructure, budget plan, and other elements of the defense program and policies required by Title 10, Section 118 of the United States Code. The Secretary of Defense is responsible for conducting a quadrennial defense review every four years to determine the United States defense program for the next 20 years. Previous reviews included the 1991 Base Force Review, the 1993 Bottom-Up Review, and the 1995 Commission on Roles and Missions of the Armed Forces as well as QDR 97 and QDR 01. The QDR 06 is the sixth complete review of the U.S. Armed Forces since the end of the Cold War, and significantly improves the Joint Manpower Exchange Program by directing the Services to form joint, fulltime manned operational JTF headquarters.

To address the QDR 06 requirement, the Services, Joint Forces Command and combatant commands, must agree on the requisite JTF capability for each Service headquarters. Although the requisite capability has not yet been defined, three organizational options are suggested below for the transformation of Service headquarters:

1. Transform Service headquarters by building a proto-typical JTF headquarters staff structure.
2. Designate a specified JTF headquarters capability based on likely missions for each type of Service headquarters.
3. Develop and man an initial operational/minimum mission essential warfight capability that is identical for all Service headquarters.

1.2 Scope and Assumptions

The scope of this research is limited to analysis of 3-star service headquarters and did not consider 2-star service headquarters. The U.S. Army Division headquarters is the most likely 2-star operational headquarters that could function as a JTF headquarters. The U.S. Army Division headquarters have recently adopted a modular design that will incorporate capabilities similar to those of the Army Corps headquarters. This research did not address the number of 3-star and 2-star Service headquarters required to maintain a rotational capability for current

and future contingencies. The following assumptions were used in the analysis of JTF headquarters alternatives:

1. JTF capable Service headquarters are not required to provide joint command and control across the full range of military operations.
2. Service headquarters will not replicate all JTF headquarters capabilities.
3. Existing joint command and control organizations such as, the Standing Joint Task Force Headquarters and Standing Joint Force Headquarters Core Element will continue to exist.
4. The Joint Manpower Exchange Program can be refined to meet the manning requirements in both JTF headquarters and Service headquarters.

1.3 Research Goals

The primary research problem of this paper is to analyze organizational options for a JTF capable Service headquarters and for each option, complete an analysis of alternatives that can be used to recommend a reorganization option to accomplish the QDR 06 directive. This paper:

1. Analyzes three alternatives to transform Service headquarters.
2. Recommends an alternative.
3. Investigates computer based modeling, specifically, the use of Multi-Agent Systems, to transform 3-star Service headquarters in the Army, Navy, Air Force and Marine Corps into operational level JTF headquarters.

A secondary research problem for this paper is to develop a methodology for analyzing headquarters alternatives that can be applied by the Services, combatant commands and Joint Forces Command. The methodology uses the Analytic Hierarchy Process to complete a pair-wise comparison of alternatives based on evaluation criteria developed from Joint doctrine. The Analytic Hierarchy Process is a multi-criteria decision making technique that is "especially suited for application to problem evaluation in which qualitative factors dominate".[4]

CHAPTER 2: DEPARTMENT OF DEFENSE DIRECTIVES FOR JOINT COMMAND AND CONTROL CAPABILITIES

Over the past six years, the Defense Department mandated improvements to joint command and control capabilities through specific strategic guidance brought forward by the Quadrennial Defense Review 2001 (QDR 01). This resulted in improved joint headquarters capabilities and initiated a shift toward capabilities-based planning. QDR 01 also initiated the move toward joint command and control capabilities down to the operational Service headquarters through networked joint command and control systems with tailorable and interoperable communications systems. Additionally, QDR 01 established the requirement for a Standing Joint Task Force Headquarters in each of the Unified Commands.[5] The Standing Joint Task Force Headquarters includes a fulltime joint command and control element with "uniform, standard operating procedures, tactics, techniques, and technical system requirements, with the ability to move expertise among commands."[6] Figure 1 below depicts the six unified commands and areas of responsibility: U.S. Pacific Command, U.S. Central Command, U.S. Northern Command, U.S. Southern Command, U.S. Joint Forces Command, and U.S. European Command.

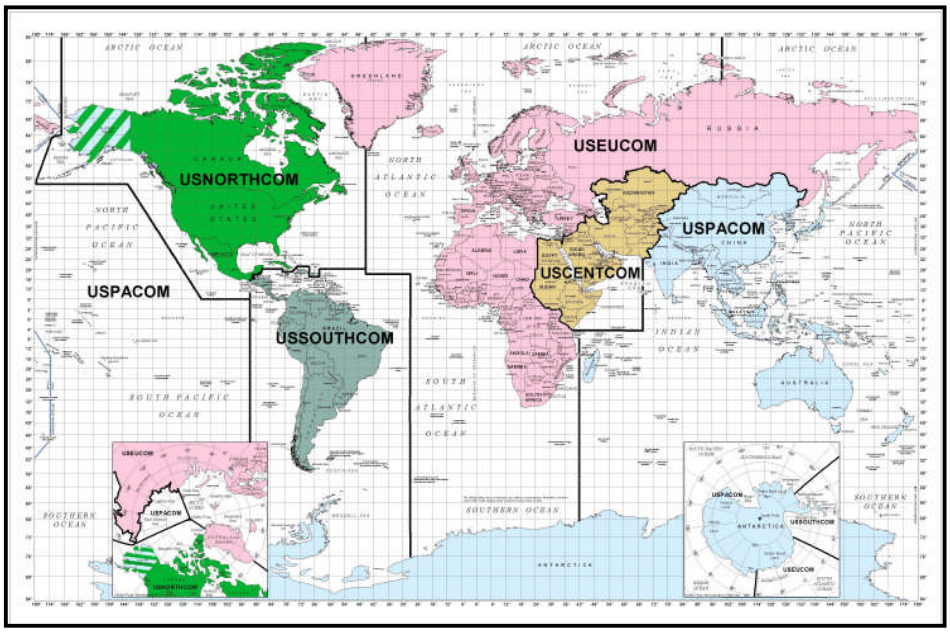

FIGURE 1: GEOGRAPHIC COMBATANT COMMANDS[7]

The establishment of Standing Joint Task Force Headquarters has been enthusiastically accepted by all military services as a capability that advances the combatant commander's ability to conduct deliberate and crisis action planning. Staffed with experienced joint qualified personnel, this headquarters is capable of collaborative planning and training with "other GCC [Geographic Combatant Command] staff elements and designated component planning cells for specified contingencies within the combatant command's area of responsibility."[8] It is important to note that the Standing Joint Task Force Headquarters is not necessarily organized to function as a fully capable JTF headquarters without additional augmentation. Augmentation includes mission specific liaison elements. The QDR 01 directed that one Standing Joint Task Force Headquarters be established for each combatant command. For example, Pacific Command's design, called the Deployable Joint Task Force Augmentation Cell (DJTFAC), provides joint planning expertise and continuity from the combatant commander's planning team to accelerate the JTF planning process until deployed to a JTF.[9]

During this same time frame, the North Atlantic Treaty Organization (NATO) held a summit to investigate how to counter threats from international terrorism, hostile regimes and rogue states. The NATO summit affirmed the need for a military force capable of rapid response to crises outside of NATO's traditional area of operations.[10] In October 2003, the North Atlantic Council established the NATO Response Force which included a 2-star level Deployable JTF (DJTF) headquarters capable of planning and assessing effects based operations.[11] The DJTF headquarters is a small forward deployed footprint in the joint operations area that remains "very dependent on the reach back support from the parent headquarters".[12] Nevertheless, the DJTF headquarters provides NATO with a rapidly deployable and self-sustaining joint headquarters.

The next major DoD step forward came with the release of the Strategic Planning Guidance 2006-2011 which directed the establishment of the Standing Joint Force

Headquarters Core Element for each combatant command by fiscal year 2005.[13] The Core Element provides a tailorable joint command and control cell of 57 joint qualified service personnel to assist with the transition of a Service headquarters to JTF headquarters. MG James Soligan, former U.S. Joint Forces Command Chief of Staff, describes the Standing Joint Force Headquarters Core Element as "enablers, organized around requirements a combatant commander is most likely to need in conducting joint, multinational, [and] interagency operations."[14] The Core Element provides the combatant commander with an organization dedicated to contingency planning in a specific area of responsibility as well as a means for rapidly transitioning Service headquarters into a JTF headquarters. The Standing Joint Force Headquarters Core Element can be employed:

1. To augment core JTF headquarters staff making it fully operational.
2. To provide personnel for rapidly transitioning a Service headquarters to a JTF.
3. To augment the combatant command warfighting headquarters with additional service components.[15]

QDR 06 also provides guidance for advancing of joint command and control headquarters capabilities, such as each Service requirement to transform the 3-star, and selected 2-star headquarters, into JTF capable headquarters. To date, implementation of this guidance has been an ad hoc establishment of JTF headquarters where combatant commanders have relied on "Service component operational headquarters that are organized, trained, and equipped to execute Service headquarters missions and win [in] a tactical fight".[16] Through this directive, QDR 06 attempts to develop a rotational pool of JTF headquarters that are manned, trained and equipped to provide command and control of joint operations at the operational level of war.

Collectively, the DoD and NATO initiatives have resulted in significant advancements to joint command and control headquarters capabilities. As mentioned above, QDR 01 and Strategic Planning Guidance 06-11 directed that one Standing JTF Headquarters and one

Standing Joint Force Headquarters Core Element be established in each of the six unified commands as joint headquarters enablers. QDR 06 directs development of nineteen JTF capable 3-star level Service headquarters. Table 1 shows the four types of 3-star Service headquarters with service and functional component capabilities.

Headquarters	Quantity	Basic Capabilities
US Army Corps	3	Operational-level Army headquarters capable of rapid transition to JTF or Joint Force Land Component Command. Deployable world-wide. Provides full-spectrum operations.
US Navy Numbered Fleet HQs	5	Staffs normally split between fleet flagship and component ashore. The Second and Third Fleets are home-ported in the United States. The Fifth, Sixth and Seventh Fleets are home-ported at forward locations.
US Air Force Numbered HQs	8	Two or more wings form a Numbered Air Force (NAF). The NAF is the senior war-fighting organization of the US Air Force and conduct theater aerospace operations with assigned and attached forces.
US Marine Expeditionary Force	3	MEF includes one or more divisions in its ground combat element, one or more aircraft wings in its air combat element, and one or more force service support groups in its combat service support element.

TABLE 1: 3-STAR SERVICE OPERATIONAL HEADQUARTERS

Chapter 3 analyzes the QDR 06 directives, provides feasible alternatives, and identifies a preferred alternative for reorganizing a Service headquarters into a JTF capable Service headquarters. This chapter presents the Analytic Hierarchy Process as a method to evaluate competing headquarters design alternatives. The process uses a pair-wise comparison of alternatives to recommend an organization design for a JTF capable Service headquarters.

CHAPTER 3: REORGANIZING TO JOINT TASK FORCE CAPABLE SERVICE HEADQUARTERS

3.1 Joint Capabilities Requirements

Joint Vision 2020 clearly articulates the United States military requirement for joint capabilities in Service headquarters: "To build the most effective force for 2020, [the Services] must be fully Joint: intellectually, operationally, organizationally, doctrinally, and technically."[17] To accomplish this, the author suggests our warfighting headquarters must have permanently manned joint forces rather than forces piecemealed together just in time for operations. Today, a permanent joint element resides only at the combatant command level in the Standing Joint Force Headquarters Core Element and Standing JTF Headquarters. The QDR 06 directive attempts to address this shortfall by establishing joint Service headquarters that can act as JTF headquarters immediately upon being designated by an establishing authority. Figure 2 below depicts a basic JTF organization structure with service and functional component commands.

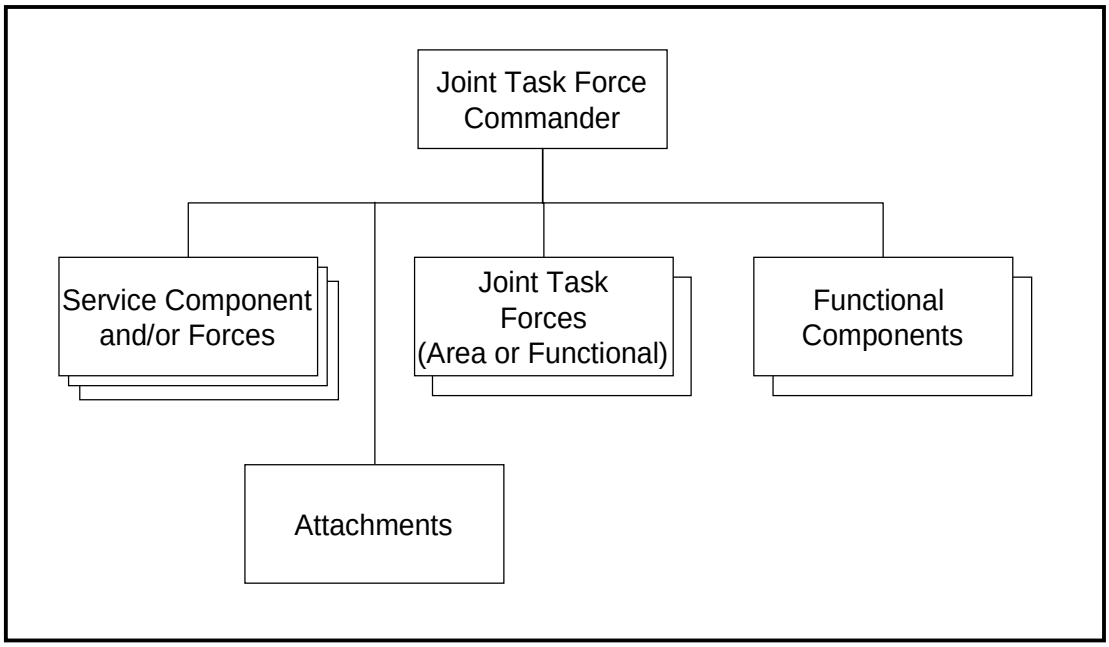

FIGURE 2: JOINT TASK FORCE ORGANIZATION

3.2 Joint Task Force

Joint Publication 3.0 defines a JTF as "a joint force that is constituted and so designated by the [Secretary of Defense], a combatant command, a subordinate unified command commander, or an existing Commander, JTF to accomplish missions with specific, limited objectives and which do not require overall centralized control of logistics."[18] The JTF organization reflects the commander's vision and concept of the operation with service components, functional components and attachments tailored to accomplish a specified mission. The fully formed staff, including service representatives or function components subordinate to the JTF, includes key positions filled appropriately by each branch of military service to accomplish the mission. For example, the JTF J-3 would normally be filled by an Army or Marine Corps senior field grade combat arms officer during a major land combat operation. Similarly, a Navy or Air Force officer might be selected for the J-3 position for maritime or air combat operations. In either case, the JTF capable Service headquarters must perform the same joint staff functions as the fully formed JTF staff including command and control, intelligence, fires, movement and maneuver, protection, and sustainment.[19]

3.3 Joint Task Force Headquarters

The JTF headquarters employs a command and control element to augment and address the full range of joint operations. Joint Publication 3-33 provides guidance and procedures for the formation and employment of a JTF as well as typical designs for the JTF headquarters staff. Joint Publication 3-33 also identifies the essential organizational structure in each Service headquarters and recognizes that JTF headquarters may vary in composition based on the range of missions assigned. Historically, JTF headquarters are assigned missions that "require execution of responsibilities involving a joint force on a significant scale and close integration of effort."[20] The JTF headquarters are responsible for integrating air, land, sea, space and special operations throughout the range of military operations. Joint Publication 3.0 defines the range of military operations as follows:

1. Military engagement, security cooperation, and deterrence activities to shape the operational environment and keep the day-to-day tensions between nations or groups below the threshold of armed conflict while maintaining US global influence.
2. Crisis response or limited contingency operations as part of a single small-scale, limited-duration operation or a significant part of a major operation of extended duration involving combat.
3. Major operation or campaign involving large-scale combat.[21]

3.4 Joint Staffs, Boards, and Centers

The Commander JTF, henceforth referred to as CJTF, is responsible for organizing forces, service and functional components to accomplish the mission. The CJTF is also legally responsible for carrying out all duties and responsibilities of the JTF headquarters. Figure 3 below depicts a typical JTF joint staff organization.

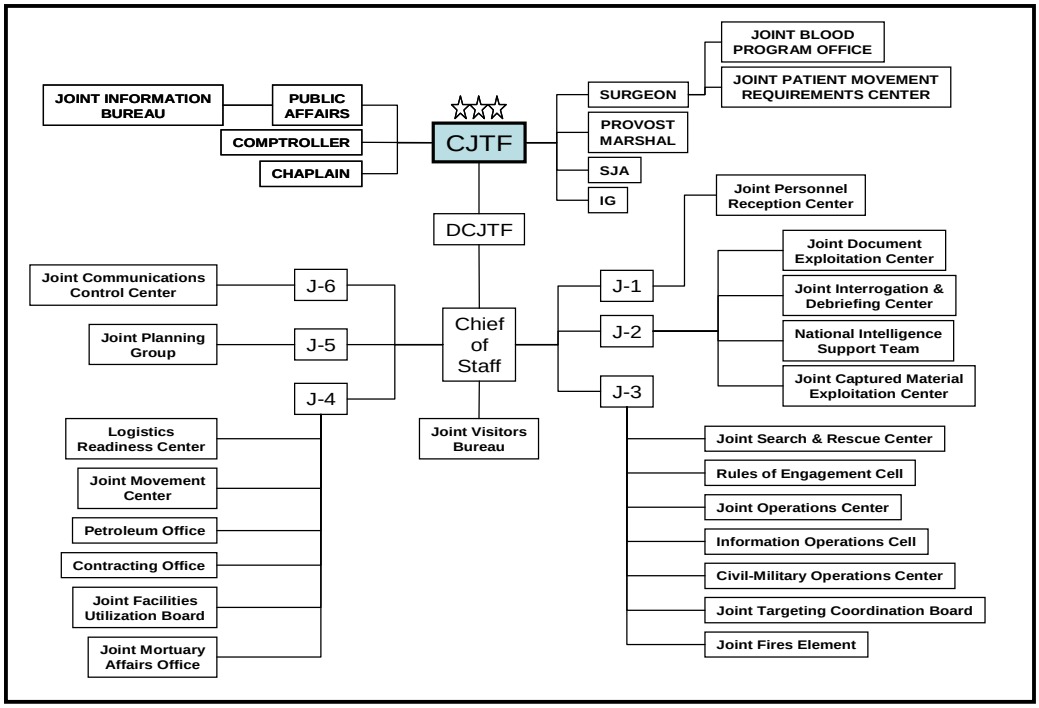

FIGURE 3: TYPICAL JTF STAFF ORGANIZATION[22]

The major challenge to accomplishing QDR 06 directives is transforming the existing Service headquarters into joint organizations with the requisite JTF staff capabilities according to Joint Publication 3.0. "The specific organization and staffing of the JTF will vary based on the

assigned mission, the operational environment, the order of battle existing and potential enemy forces, and the time available to reach the desired end state."[23] Ultimately, the commander organizes the headquarters staff with appropriate Service representatives and functional components into a fully functional JTF headquarters to meet operational requirements.

The remaining analysis in this chapter presents the Analytic Hierarchy Process as a method to evaluate competing headquarters design alternatives. The process uses a pair-wise comparison of alternatives to recommend an organization design for a JTF capable Service headquarters that can be used by the Services, Combatant Commands, and Joint Forces Command to address current and future organizational design problems.

3.5 Alternatives to Organize JTF Capable Service Headquarters

The design problem addressed by this research, to analyze options for organizing JTF capable Service headquarters, is based on three realistic alternatives presented below:

1. Proto-typical JTF staff organization as defined in Joint Publication 3-33.
2. JTF headquarters based on predetermined JTF missions and scenarios and Joint Manning Documents.
3. JTF headquarters with minimum mission essential joint personnel to provide joint campaign planning, early entry command post, initiate joint command and control and coordinate with host nation/coalition partners.

Each of these three alternatives will be evaluated based on providing joint command and control in accordance with Joint doctrine. The basic concept of each option is presented next.

3.5.1 Alternative 1: Organize Service headquarters as a typical JTF Staff headquarters

This option uses the JTF staff structure laid out in Chapter 2 of Joint Publication 3-33. In Alternative 1, the standard joint staff structure would be established in all 3-star headquarters with associated boards and centers stood up to accomplish the JTF headquarters mission. This option complies with QDR 06 requirements; however it does not mandate on what JTF capabilities would reside in the 3-star Service headquarters. The Joint Manpower Exchange Program would apply to both active and reserve component manning. Additional analysis is necessary to determine the coding of positions as DOD civilians or contractors. This JTF staff organization option is a manpower intensive alternative.

3.5.2 Alternative 2: Organize Service headquarters based on predetermined and preassigned JTF missions

This option requires consensus among civilian and military leaders as to what predetermined JTF capabilities would be assigned to each 3-star Service headquarters. Pre-determinants of capabilities would require the combatant commands to determine what JTF missions in their respective area of reasonability would likely assign to 3-star Service headquarters. The combatant commands could then associate the 3-star headquarters with specific JTF headquarters based on mission requirements. Following this, the Services could then appropriately resource 3-star headquarters for the predetermined JTF missions according to the Joint Manning Document and the Joint Manpower Exchange Program.

3.5.3 Alternative 3: Organize the Service headquarters with a minimum mission essential joint cadre

The third option recommends that the 3-star headquarters be organized with a minimum level of essential joint personnel. This option is designed to provide a Service headquarters with a JTF capability in four specific areas: (1) initial joint campaign planning; (2) early entry command and control into the Joint Operations Area; (3) shaping operations; and (4) face-to-face coordination with host nation and coalition partners. This alternative is based on the

organizational design and capability of the current U.S. Army Corps headquarters. All joint manpower resources for this option would be provided through the Joint Manpower Exchange Program.

3.6 Comparison of Alternatives

Next, the three alternatives described above are compared against the required joint command and control capabilities as specified in the February 2004 Joint Command and Control Function Concept. This document specifies, for example, that all joint command and control headquarters must be organized to execute basic and collaborative command and control functions with the overarching attribute being agility.[24] Agility is described in the Joint Command and Control Functional Concept in terms of the following attributes: responsiveness, resiliency, robustness, flexibility, adaptability, and innovativeness.

The Analytic Hierarchy Process is used to assess the three organizational alternatives. The analysis uses the evaluation criteria developed to assess each alternative's ability to accomplish joint command and control capabilities. Table 2 depicts the evaluation criteria.

Evaluation Criteria		Description
1	Multi-functionality	Satisfies both requirements for operational-level JTF headquarters while retaining readiness for service and functional component core competencies (*flexible*)
2	Scalability	The ability to operate as JTF headquarters across the range of military operations as designed (*robust, resilient*)
3	Deployability	Rapidly responsive Service component operational HQ that is JTF headquarters certified to meet a range of potential contingency requirements within a specified area of responsibility (*responsive*)
4	Acceptability	JTF-Ready HQ must have the capability to command and control joint operations using assigned or attached forces, to include multi-national forces, to accomplish assigned missions in a defined area of responsibility (*adaptive*)
5	Affordability	The ability to resource the manpower requirements

TABLE 2: EVALUATION CRITERIA FOR JOINT COMMAND AND CONTROL

3.6.1 Analysis of Headquarters Alternatives using the Analytic Hierarchy Process

The Analytic Hierarchy Process is a "multi-criteria decision technique that can combine qualitative and quantitative factors in the overall evaluation of alternatives".[25] This process

"facilitates a comprehensive and logical analysis of problems for which considerable uncertainty exists".[26] The Analytic Hierarchy Process includes four steps:

1. Decide upon the criteria for selection.
2. Rate the relative importance of these criteria using pair-wise comparisons.
3. Rate each potential choice relative to each other choice on the basis of each selection criterion achieved by performing pair-wise comparisons of the choices.
4. Combine the ratings derived in steps 2 and 3 to obtain an overall relative rating for each potential choice.[27]

The process outcome "determines the priority any alternative has on the overall goal of the problem of interest".[28] Figure 4 illustrates the hierarchical representation of the headquarters analysis according to an Analytic Hierarchy Process tree. At the top level of the hierarchy is the over-arching objective or goal to be accomplished through an analysis of decision alternatives under consideration. At the next level of the problem, are the five criteria of effectiveness for analyzing each alternative's ability to accomplish joint command and control are listed. Finally, the three JTF capable Service headquarters organization alternatives are shown.

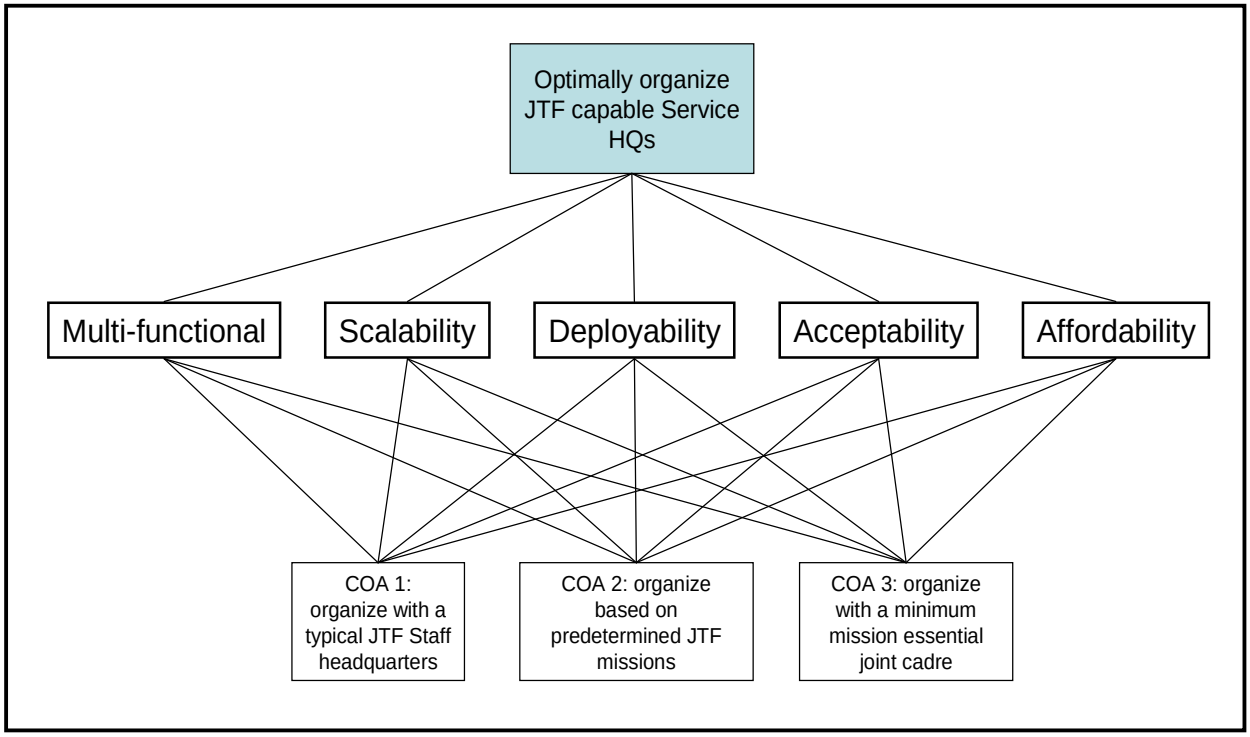

FIGURE 4: ANALYTIC HIERARCHY PROCESS TREE

3.6.2 Pair-wise Comparison of Evaluation Criteria

A pair-wise comparison of criteria generates a table of relational data for comparing alternatives. The pair-wise comparison is made at all levels of the Analytic Hierarchy Process tree to determine the "relative priority of each attribute to each attribute one level up in the hierarchy".[29] The Analytic Hierarchy Process uses the relational scale of real numbers from 1 to 9 to systematically assign preferences.[30] Using this scale, a pair-wise comparison is conducted at each level relative to each element at the next higher level in the hierarchy.

To begin the comparison, each criterion is compared against all other criterion with respect to the objective to organize a JTF capable Service headquarters. The relational scale of real numbers will be used when actual quantitative values have not been determined. The evaluation criteria, as defined in Table 2, provide the measures used to determine the relative importance of each criterion. The following methodology is applied when the evaluation is based on qualitative factors:

1 – Criterion A and B are of equal importance.

3 – Criterion A is weakly more important than B.

5 – Criterion A is strongly more important than B.

7 – Criterion A is very strongly more important than B.

9 – Criterion A is absolutely more important than B.

Intermediate values of 2, 4, 6, and 8 may also be applied in the pair-wise comparison.[31]

The Pair-wise analysis process compares each evaluation criterion with the every other criterion; one at a time, to establish the importance of each criterion to organizing a JTF capable Service headquarters. This establishes local priority or relative weight to be applied later in the ranking of alternatives found in section 3.6.5. Figure 5 shows an example of a pair-wise comparison of two evaluation criteria: Affordability and scalability.

Evaluation Criteria: Affordability and Scalability

Comparison: Affordability is strongly more important than Scalability with regards to organizing a JTF capable Service headquarters.

Scoring: using the relational scale of real values, the criterion affordability is determined to be five times more important than scalability thereby generating a score of 5 for Affordability. The reciprocal score, 1/5 (one fifth), is applied to Scalability.

Result: The score reflects a relative importance between the two criteria.

Criteria	Scalability	Affordability
Affordability	5	
Scalability		1/5

FIGURE 5: PAIR-WISE COMPARISON OF AFFORDABILITY TO SCALABILITY

Continuing with the example given above, we generate the output of the pair-wise comparison for all five criteria used for evaluating headquarters alternatives. Results provided in Table 3 reflect the relative importance of a criterion in a certain level with respect to the objective above it in the Analytic Hierarchy process tree. The rankings reflect the author's judgment of relative importance for each of the criterion. These conclusions are based on the

scope of research that went into this project to include discussions with subject matter experts at JFCOM, the U.S. Army Combined Arms Center and the U.S. Navy's 2nd Fleet Headquarters, analysis of current joint doctrine, and seven years of force management experience in U.S. Army. The ranking of each criterion is discussed next.

3.6.2.1 Pair-wise Comparison of Affordability and Multi-functionality

Affordability addresses the ability to resource the manpower growth in each alternative. Multi-functionality addresses the constraint to operate as a JTF headquarters while retaining readiness for service and functional component core competencies. The pair-wise comparison is conducted to determine the relative importance of these two criteria to organizing a JTF capable Service headquarters.

- The relative importance of Affordability is high due to the limitations on manpower growth in all four Services. The manpower growth must address the reserve component's role to augment Service headquarters and account for the impacts to existing reserve component force structure already missioned to provide requisite forces to the warfight. The manpower growth to active forces is also a major concern, specifically to the Army and Marine Corps. Any active component manpower growth will come at the expense of combat and support forces required to sustain worldwide rotational and contingency requirements.
- The relative importance of Multi-functionality is also high to satisfy the requirements to operate as a JTF headquarters, service and functional component headquarters. The QDR 06 directive is not intended to transform all 3-star Service headquarters into standing JTF headquarters, but fully recognizes the service and functional component headquarters missions that will remain a primary requirement as part of a larger JTF.

Based on these points, both criteria must be determined to be of equal importance when organizing a JTF headquarters. This fact generates a ranking of 1. Due to the equal importance of both Affordability and Multi-functionality, the comparisons against all other criterion will be identical for these two criteria.

3.6.2.2 Pair-wise Comparison of Affordability and Multi-functionality against Scalability

Scalability addresses the ability to operate as JTF headquarters across the range of military operations.

- The Scalability addresses the categories of JTF headquarters and their associated mission scope. The categories of JTF headquarters include rotational, Homeland Defense and contingency headquarters. The contingency headquarters category includes the JTF headquarters missions for disaster relief, Security, Stability, Transition, and Reconstruction operations, Small Scale Contingency operations and Major Combat Operations.
- The majority of JTF headquarters contingency requirements have been in the disaster relief to Small Scale Contingency range of military operations. Additionally, not all Service headquarters should or would be assigned JTF headquarters responsibilities across the range of military operations. Historically, U.S. Air Force and U.S. Navy numbered headquarters have not been assigned JTF headquarters responsibilities for major combat operations involving large scale ground combat such as Iraq and Afghanistan.

Based on this analysis, Scalability is not a critical criterion and is deemed strongly less important than Affordability and Multi-functionality. Using the real value evaluation methodology, this generates a ranking of one-fifth (1/5) for Scalability and the reciprocal of 5 for both Affordability and Multi-functionality.

3.6.2.3 Pair-wise Comparison of Affordability and Multi-functionality against Deployability

Deployability addresses the requirement for a rapidly responsive Service component headquarters that is JTF headquarters certified to meet all potential contingency requirements within a specified area of responsibility.

- Rapid deployability is a critical task for the JTF capable Service headquarters. More than 80 percent of major military operational contingencies have less than one month of planning time before execution.[32] This fact shows the importance to rapidly form and deploy the JTF headquarters.
- Deployability supports the QDR 06 requirement to provide JTF capable Service headquarters available to immediately command and control integrated joint operations as part of Unified Action.

Based on the above requirements, Deployability is determined to be weakly less important than Affordability and Multi-functionality. The real value scale generates a score of one-third (1/3) for Deployability and the reciprocal of 3 is assigned to both Affordability and Multi-functionality.

3.6.2.4 Pair-wise Comparison of Affordability and Multi-functionality against Acceptability

Acceptability addresses the requirement of a JTF-Ready headquarters to command and control joint operations using assigned or attached forces, to include multi-national forces, to accomplish assigned missions in a defined area of responsibility.

- Acceptability looks at the formation and design of the JTF capable Service headquarters. The acceptable JTF headquarters will be organized to provide joint command and control for integrated operations using an effects-based approach, including the boards, centers and cells necessary to provide this capability.[33]

- In contrast to Multi-functionality, which addresses the ability to serve as a JTF headquarters and as a service or functional component headquarters, Acceptability addresses only the ability to serve as a JTF headquarters.

Due to the above points, Acceptability is determined to be weakly less important than Affordability and Multi-functionality. This ranking generates a score of one-third (1/3) for Acceptability and generates a score of 3 for both Affordability and Multi-functionality.

3.6.2.5 Pair-wise Comparison of Deployability and Scalability

Deployability addresses the requirement for a rapidly responsive headquarters and is a significant condition for all JTF capable Service headquarters. Scalability addresses the ability to operate as JTF headquarters across the range of military operations and was previously determined to be of lesser importance because not all Service headquarters would be assigned JTF responsibilities across the range of military operations.

Due to the above assessments, the criterion of Deployability is determined to be strongly more important than Scalability. This analysis generates a score of 5 for Deployability and a score of one-fifth (1/5) for Scalability.

3.6.2.6 Pair-wise Comparison of Acceptability and Scalability

As previously discussed, the criterion of Acceptability specifies the requirement for a JTF capable Service headquarters to command and control joint operations. The criterion of Scalability concentrates on the ability to operate as JTF headquarters across the range of military operations. Based on a review of Joint doctrine, there are no indications of relative importance for these two criteria. The justification for pair-wise comparison is based on the requirement for all JTF capable Service headquarters to meet the criterion of Acceptability, while only selected JTF capable Service headquarters must meet the criterion of Scalability.

Scalability is a lesser required capability that is not essential in all JTF capable Service headquarters.

Due to this assessment, the criterion of Acceptability is strongly more important than Scalability. This analysis generates a score of 5 for Acceptability and applies the reciprocal of one-fifth (1/5) to Scalability.

Table 3 provides the consolidated pair-wise comparison values for the five evaluation criteria. In the Analytic Hierarchy Process, these rankings reflect the local priority for the five evaluation criteria.

Criteria	Affordability	Multi-functionality	Scalability	Deployability	Acceptability
Affordability	1	1	5	3	3
Multi-functionality	1	1	5	3	3
Scalability	1/5	1/5	1	1/5	1/5
Deployability	1/3	1/3	5	1	1
Acceptability	1/3	1/3	5	1	1

TABLE 3: PAIR-WISE COMPARISON OF CRITERIA

The next step in the Analytic Hierarchy Process is to compute a composite ranking of all criteria based on the pair-wise comparison results. The ranking is accomplished through determining an eigenvector solution. The eigenvector methodology applied here was developed by Dr. Thomas L. Saaty from the Joseph M. Katz Graduate School of Business, University of Pittsburgh.

3.6.3. Eigenvector Method

The eigenvector methodology generates an estimated relative weight for each decision element [criterion].[34] In calculating the estimated relative weights for the criteria, all fractions are converted to decimals (to the fourth place in our case) in Table 3 as shown. Next, each value in the matrix is squared and each row is summed. The resultant eigenvector is determined by normalizing the sum of each row to give a relative weight, or ranking, for each criterion.

The eigenvector for each criteria provides a relative ranking that will be used later to compute the best alternative. The eigenvector scores reflect the importance of a given criterion, with the largest score as the most important criterion. For this problem, Affordability and Multi-functionality are the most important criteria with an eigenvector score of .3402. Deployability and Acceptability are the second most important criteria with an eigenvector of .1386. Scalability is the least important criterion for organizing a JTF capable Service headquarters with an eigenvector score of .0423. Table 4 shows the resultant relative weights for the criteria to be used later in section 3.6.5 for the analysis of alternatives and development recommendations.

Criteria	Afford.	Multi-.	Scalab.	Deploy.	Accept.	Sum	Eigenvector
Affordability	5.0000	5.0000	45.0000	13.0000	13.0000	81.0000	0.3402
Multi-functionality	5.0000	5.0000	45.0000	13.0000	13.0000	81.0000	0.3402
Scalability	0.7333	0.7333	5.0000	1.8000	1.8000	10.0667	0.0423
Deployability	2.3333	2.3333	18.3333	5.0000	5.0000	33.0000	0.1386
Acceptability	2.3333	2.3333	18.3333	5.0000	5.0000	33.0000	0.1386
						238.0667	1.0000

TABLE 4: RELATIVE WEIGHTS FOR CRITERIA

The next step in the Analytic Hierarchy Process is to complete a pair-wise comparison for each alternative with respect to each individual criterion.

3.6.4 Pair-wise Comparison of Alternatives

A pair-wise comparison is now made for each alternative relative to the five criteria. The comparison uses the relational scale of real numbers from 1 to 9 and real values, if available, to determine local priority. The first pair-wise comparison looks at each of the three alternatives with respect to Affordability. This comparison establishes a relative importance and ranking of each alternative for the criterion of Affordability. Appendix A shows the complete set of results for all pair-wise comparisons of alternatives.

3.6.4.1 Pair-wise Comparison of Alternatives to Affordability

For this comparison, real values are presented from estimates of manpower growth. The following shows the estimated manpower growth for all three alternatives:

- Alternative 1: 100 personnel. This alternative is most closely represented by the ongoing work by the U.S. Navy 2nd Fleet. The initial staff estimates show a growth of approximately 100 personnel to the Fleet headquarters.
- Alternative 2: 57 personnel. This alternative does not have specific manpower numbers. A valid estimate for required manpower is to apply the 57 personnel of the Standing Joint Force Headquarters Core Element.
- Alternative 3: 17 personnel. The manpower growth for this alternative is based on the recommendations of the U.S. Army Corps headquarters JTF augmentation of approximately 17 personnel.

The scoring for a given alternative reflects the amount of manpower growth in comparison to the other two alternatives. Based on the example provided in section 3.6.2, reciprocal numbers are used in the scoring.

- Alternative 1 organizes the Service headquarters as typical JTF staff headquarters with a manpower growth of 100 personnel. In comparison to Alternative 2, this option is about twice the size which is shown as a score one-half (1/2). The comparison to Alternative 3 shows that this option is six times the size and generates a score of one-sixth (1/6).

- Alternative 2 organizes the Service headquarters based on predetermined and preassigned JTF missions with a manpower growth of 57 personnel. Alternative 2 is half the size of Alternative 1 and generates a score of 2. Alternative 2 is four times the size of Alternative 3, which is scored as one-fourth (1/4).

- Alternative 3 organizes the Service headquarters with a minimum mission essential joint cadre with a manpower growth of 17 personnel. Alternative 3 is one-sixth (1/6) the size of Alternative 1 and one-fourth (1/4) the size of Alternative 2, scored as 6 and 4 respectively.

The next step in the Analytic Hierarchy Process is to compute the ranking of priorities from the pair-wise matrix using the same matrix algebra methodology from section 3.6.3. Again, all fractions are converted to decimals and then the matrix is then squared and each row is summed. Finally, the eigenvector is determined by normalizing the sum of each row to develop a relative weight for each alternative for Affordability. The largest eigenvector score reflects the best alternative to accomplish the criterion of Affordability.

1. Alternative 3 is the highest ranked alternative with a score of .7016.
2. Alternative 2 is the second ranked alternative with a score of .1926.
3. Alternative 1 is the lowest ranked alternative with a score of .1058.

The eigenvector method is now applied to the remaining four criteria using the same process. In contrast to Affordability, quantitative values are not available to determine relative ranking of the alternatives for the four remaining criteria. To complete the pair-wise comparison, the analysis will use the relational scale of real numbers from 1 to 9 as previously presented in section 3.6.2. The same process is now applied to the remaining four criteria: Multi-functionality, scalability, deployability, and acceptability.

3.6.4.2 Pair-wise Comparison of Alternatives to Multi-functionality

The second pair-wise comparison looks at each of the three alternatives with respect to multi-functionality to establish the relative importance and ranking of each alternative. The scoring is a qualitative evaluation of alternatives based on the scope of research that went into this project.

Alternative 1 organizes the Service headquarters as typical JTF staff headquarters which provides the highest level of multi-functionality capabilities relative to all other alternatives. Alternative 2 organizes the Service headquarters based on predetermined and preassigned JTF missions providing a focused JTF capability for selected JTF headquarters missions. Alternative 3 organizes the Service headquarters with a minimum mission essential joint cadre

designed to accomplish joint campaign planning, early entry command and control and coordination with host nation/coalition partners. Alternative 3 is the least multi-functional JTF headquarters design.

Based on these capabilities, the qualitative evaluation process generates the following evaluations:

- Alternative 1 is strongly more capable than Alternative 2 scored as 5.
- Alternative 1 is absolutely more capable than Alternative 3 scored as 9.
- Alternative 2 is strongly more capable than Alternative 3 scored a 5.
- Alternative 2 scoring against Alternatives 1 has already been analyzed, therefore the reciprocal, one-fifth (1/5), is applied.
- Alternative 3 scoring against Alternatives 1 and 2 are the reciprocal of previous scoring, one-ninth (1/9) and one-fifth (1/5) respectively.

The largest eigenvector score reflects the best alternative to accomplish the criterion of Multi-functionality.

1. Alternative 1 is the highest ranked alternative with a score of .7432.
2. Alternative 2 is the second ranked alternative with a score of .2026.
3. Alternative 3 is the lowest ranked alternative with a score of .0542.

Based on the eigenvector scoring, Alternative 1 is the best alternative to organize a JTF headquarters while retaining readiness for service and functional component core competencies.

3.6.4.3 Pair-wise Comparison of Alternatives to Scalability

The third pair-wise comparison looks at each of the three alternatives with respect to Scalability. This comparison establishes a relative importance and ranking of each alternative for the criterion of Scalability using a qualitative evaluation of alternatives.

Alternative 1 is the most robust JTF headquarters formed along traditional staff lines with requisite boards, centers, cells and working groups as defined in JP 3-33. This alternative can

rapidly scale up or down based on the JTF mission with minimum augmentation. Alternative 2 provides a predetermined JTF headquarters capability to each Service headquarters with selected boards, centers, cells and working groups necessary for the specified JTF mission. The predetermined JTF headquarters capability will minimize the requirements to scale up or down the headquarters to accomplish the mission. Alternative 3 provides the least robust JTF headquarters with minimum joint manning to accomplish initial joint campaign planning, early entry capabilities and begin shaping operations. This alternative will require significant augmentation to operate across the range of military operations. Based on this analysis, a qualitative assessment generates the following evaluations:

- Alternative 1 is weakly more capable than Alternative 2 scored as 3.
- Alternative 1 is very strongly more capable than Alternative 3 scored as 7.
- Alternative 2 is strongly more capable than Alternative 3, which is scored as 5.
- Alternative 2 has already been analyzed in comparison to Alternative 1, therefore the reciprocal of one-third (1/3) is applied to complete the analysis.
- Alternative 3 scoring against Alternatives 1 and 2 are the reciprocal of previous scoring, one-seventh (1/7) and one-fifth (1/5) respectively.

Based on the evaluations provided above, the largest eigenvector score reflects the best alternative to accomplish the criterion of Scalability.

1. Alternative 1 is the highest ranked alternative with a score of .6535.
2. Alternative 2 is the second ranked alternative with a score of .2772.
3. Alternative 3 is the third ranked alternative with a score of .0693.

3.6.4.4 Pair-wise Comparison of Alternatives to Deployability

The fourth pair-wise comparison evaluates each of the three alternatives with respect to Deployability. The scoring remains a qualitative evaluation of alternatives. The following explanations are provided to clarify scoring of each alternative with regards to deployability of the JTF capable Service headquarters.

A responsive JTF capable Service headquarters is required to meet specified deployment timelines. As seen with NATO's Deployable JTF headquarters, the deployment timeline specifies that the headquarters will deploy within 5 days of alert with specific time horizons mandated for headquarters planning: Current operations, 0 to 72 hours; future operations, 3 to 10 days; and future plans, 11 to 30 days.[35] Using a similar deployability requirement, Alternative 2 provides the best alternative to accomplish a responsive JTF headquarters capability. Due to the predetermined JTF mission, the Services can organize, train, equip and certify the headquarters, which will provide an immediately available JTF headquarters capable of commanding and controlling integrated joint operations with minimal time to deploy. In contrast, Alternative 1 and Alternative 3 require time to organize, train, equip and complete mission specific certification prior to deployment.

- Alternative 1 and Alternative 3 have equal capabilities and receive the same pair-wise score of 1.
- Alternative 1 is strongly less capable than Alternative 2 and is scored as one-fifth (1/5).
- Alternative 2 is strongly more capable than Alternative 1 as defined above generating a score of 5.
- Alternative 2 is weakly more capable than Alternative 3 scored as 3.
- Alternative 3 scoring against Alternatives 1 is scored as 1 due to equal capabilities.
- Alternative 3 scoring against Alternative 2 is the reciprocal of previous scoring, one-third (1/3).

Based on the evaluations provided above, the largest eigenvector score reflects the best alternative to accomplish the criterion of Deployability.

1. Alternative 2 is ranked highest with a score of .6607
2. Alternative 3 is ranked second with a score of .1843.
3. Alternative 1 is ranked third with a score of .1550.

From the eigenvector scoring, Alternative 2 is the best option to for organizing a responsive JTF capable Service headquarters certified to meet a range of contingency requirements within a specified area of responsibility.

3.6.4.5 Pair-wise Comparison of Alternatives to Acceptability

The final pair-wise comparison evaluated the three alternatives with respect to Acceptability. The scoring is a qualitative evaluation of alternatives. The following analysis is provided to clarify the scoring with regards to acceptability of the headquarters as a JTF, service or function component command.

As previously discussed, Acceptability addresses the requirement of a JTF-Ready headquarters to command and control joint operations using assigned or attached forces, to include multi-national forces, to accomplish assigned missions in a defined area of responsibility. The acceptable JTF headquarters will be organized to provide joint command and control for integrated operations using an effects-based approach, including the boards, centers, cells and working groups necessary to provide this capability. As defined in section 3.5, Alternative 1 incorporates all of the JTF headquarters staff sections, boards, centers, cells and working groups to accomplish the major tasks for a JTF headquarters, service and functional component command. Due to the predetermined JTF mission, Alternative 2 provides an acceptable design that is organized with the all augmentation necessary for the predetermined JTF headquarters mission. Alternative 3 is the least acceptable design because it remains truly a Service headquarters with minimum essential joint personnel for joint planning, early entry requirements and initial shaping operations. The following qualitative evaluations are provided:

- Alternative 1 and Alternative 2 have equal capabilities and receive the same pair-wise score of 1.
- Alternative 1 is strongly more capable than Alternative 3 for this criterion, generating a score of 5.
- Alternative 2 is strongly more capable than Alternative 3, generating a score of 5.
- Alternative 3 scoring against Alternatives 1 and 2 are the reciprocal of previous scoring, one-fifth (1/5) and one-fifth (1/5) respectively.

Based on the evaluations provided above, the largest eigenvector score reflects the best alternative to accomplish the criterion of Acceptability.

1. Alternative 1 and 2 are both ranked highest with a score of .4545.
2. Alternative 3 is ranked third with a score of .0909.

From the eigenvector scoring, Alternatives 1 and 2 are equally valid options to accomplish the organizational design problem.

The final step in the Analytic Hierarchy process is to complete the ranking of alternative using the eigenvector scores determined in the pair-wise comparison of alternatives and the pair-wise comparison of criteria.

3.*6.5 Ranking of Alternatives*

The eigenvectors of the criteria as well as the eigenvectors determined for each alternative are used in the calculations to determine the preferred alternative. To determine the highest ranked alternative, the eigenvector for each criterion is multiplied by the corresponding criterion eigenvector for a specific alternative. These values are then summed across for each alternative. The summed value is the relative ranking for the alternative and establishes the global priority for that alternative. The following equation is provided for clarification:

ALTERNATIVE 1 = (.3402*.1058) + (.3402 * .7432) + (.0423 * .6535) + (.1386 * .1550) + (.1386 * .4545) = .4010

The global priority reflects the importance of an alternative with respect to the objective. Based on the criteria developed, the table shows that the highest ranked alternative using the Analytic Hierarchy Process is the Alternative 1 with a score of .4010. The Analytic Hierarchy Process determined that Alternative 1 provides the best solution using the given criteria for analysis. Alternative 2 is the second best option to solve the organizational design problem with a score of .3008. Alternative 3 is the least preferred option with a score of .2983. Table 5

shows the consolidated calculations and ranking of alternatives from the Analytic Hierarchy Process.

Eigenvectors	Affordability	Multi-functional	Scalability	Deployability	Acceptability	
Criteria	0.3402	0.3402	0.0423	0.1386	0.1386	ALT Ranking
ALT 1	0.1058	0.7432	0.6535	0.1550	0.4545	0.4010
ALT 2	0.1926	0.2026	0.2772	0.6607	0.4545	0.3008
ALT 3	0.7016	0.0542	0.0693	0.1843	0.0909	0.2983

TABLE 5: OVERALL RANKING OF ALTERNATIVES USING ANALYTIC HIERARCHY PROCESS

3.7 Recommendations for Organizing JTF Capable Service Headquarters

The Analytic Hierarchy Process suggests the proto-typical JTF headquarters design provides the best alternative to solve the QDR 06 directive using the five selected criteria. Additional refinements to the results may be determined through modifications to the evaluation criteria. Based on this design alternative, affordability will remain a major factor to implement across 21 3-star Service headquarters as well as 2-star Service headquarters in the Army. The projected manpower bill will be substantial for the Services which will only be reduced through reorganization and refinements to the proto-typical JTF staff sections. As part of this research, the next chapter investigates the use of modeling and simulation as a tool to reorganize JTF headquarters staffs to accomplish the QDR 06 directive.

CHAPTER 4: USING MODELING AND SIMULATION TO ANALYZE THE JTF ORGANIZATIONAL DESIGN PROBLEM

Chapter 4 investigates the application of modeling and simulation methods to analyze options for reorganizing a Service headquarters for specific JTF missions. This analysis combines the theory of multi-agent systems modeling to study the organizational framework of the JTF headquarters.

4.1 Methodology

In most circumstances, it is not practical, nor necessary, to model all aspects of a complex organization framework such as a JTF headquarters. In modeling complex organizations, the organization is often sub-divided into manageable components allowing a smaller scale model to be rendered for each sub-component or sub-process built to efficiently analyze the system. Therefore, the problem considered here will be bounded to a JTF staff section as component part of the JTF headquarters. For this analysis, the application of modeling and simulation of agent-based models will be applied to the G-3 Plans Cell (operations) of a typical U.S. Army Corps headquarters.

Multi-Agent Systems modeling lends itself to provide an efficient tool to analyze small organizational frameworks to solve problems that require self-organization and adaptation. Adaptive Multi-Agent Systems modeling incorporates a model of goals, roles, agents, capabilities and relationships between them. In this research, Multi-Agent Systems modeling is investigated as a method to analyze the joint manning requirements to optimize staff capabilities of the JTF headquarters. The Multi-Agent Systems analysis in this chapter is an adaptation of previous research work by Scott Deloach and Eric Watson from Kansas State University called "An Organizational Model for Designing Adaptive Multiagent Systems"[36] and a subsequent analysis on organizational transition called "Formal Transition in Agent Organizations"[37].

The overall goal of Multi-Agent Systems modeling is to build intelligent systems that can adapt effectively to changes internally within the system or externally with their environment.[38]

The organizational model framework is defined by the organization diagram or design document that details the organizational structure with specified requirements for personnel. The research problem will use the U.S. Army Table of Organization and Equipment (TO&E) to define the organizational structure of the G-3 Plans Cell. The TO&E is an organizational design document based on current doctrine and available equipment and shows the military unit's structure and wartime requirements for both personnel and equipment. The TO&E provides a framework for analyzing the roles various individuals play and how they interact to achieve organization wide goals. The organization goals are defined by the joint mission essential tasks necessary to achieve a specific JTF headquarters capability as recommended in Chapter 3.

4.2 Multi-Agent Systems Organization Model

Feber, Gutknecht and Michel define an organization as a collection of roles that stand in certain relationship to one another, and that take part in systematic institutionalized patterns of interactions with other roles.[39] The organizational model includes agents which play roles within a structure in order to satisfy a given set of organizational goals. The following definitions detail the organizational model:

- Agent is an individual that manifest a behavior and provides a set of services available to every other agent.
- Role is a description of an abstract behavior of the agent that includes constraints such as the responsibilities, obligations, requirements and skills that the agent will have to satisfy to obtain a role.[40]

In the context of this research problem, a class of model agents can be used to represent the behaviors of military personnel performing duties assigned to the JTF headquarters. The representation of agent behaviors are defined according to duties performed given the role that is defined by a particular position description, military job classification and

associated rank or grade and requisite skill required to perform the job. The role must also describe the pattern of interactions in which agent playing that role will have to perform.

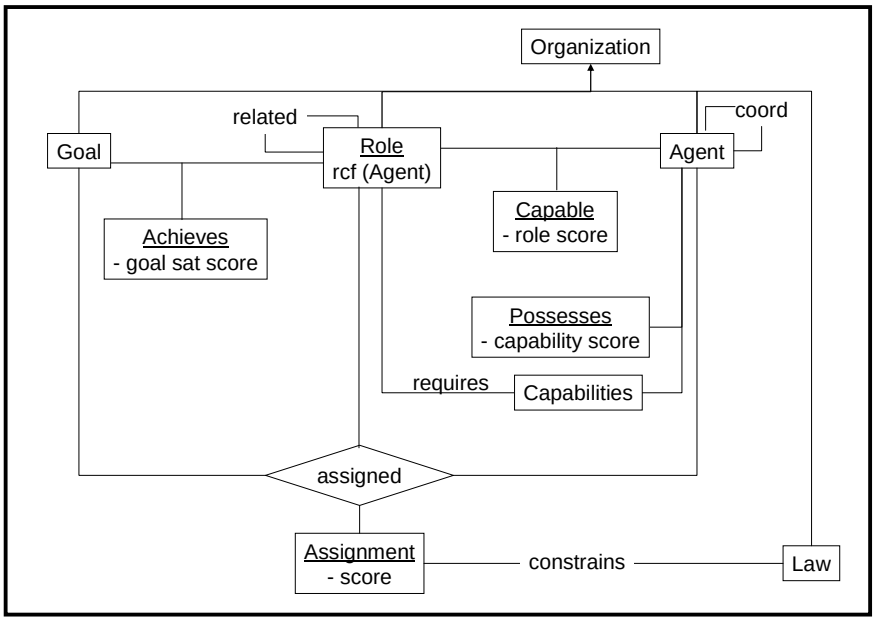

FIGURE 6: DELOACH MATSON ORGANIZATION MODEL [41]

4.2.1 Mathematical Formulation of the Organizational Model

Mathematical notation for the problem is as follows.

O = the organization over which the transition will occur

Φ = the set of properties that can trigger a transition of the organization

δ = the transition function

S_n = the set of relative states of the organization

$S_{optimal}$ = the set of optimal states that result from transition

$S_{possible}$ = states that are possible to reach, from the current state

S_{final} = a set of organization states where all goals are satisfied, or the 1st goal is satisfied, or it is determined that not all goals can be satisfied

4.2.2 Organizational Structure Model

Deloach and Matson proposed an organizational model that contains a structure model, a state model and a transition function defined as $O=<O_{struct}, O_{state}, O_{trans}>$.[42] The structural model includes a set of goals (G) that the [organization] is attempting to achieve, a set of roles (R) that must be played to attain those goals, a set of capabilities (C) required to play those roles, and a set of rules or laws(L) that constrain the organization.[43] The model also includes static relations between roles and goals (*achieves*), roles and capabilities (*requires*), individual roles (*related*), and goals (*subgoal* and *precedes*).[44] The organizational structure is formally defined as O_{struct} = <G, R, L, C, achieves, related, requires, subgoal, precedes> which form the model requirements for the JTF headquarters design problem. Using the organizational structure, O_{struct}, the next requirement is to define the roles, goals and capabilities for the organization under analysis.

To incorporate the Deloach and Matson organizational model into the design problem for a JTF headquarters, the conventional military definitions for a personnel description are mapped to the modeling parameters. As previously discussed, a class of model agents can be used to represent the behaviors of military personnel performing duties assigned to the JTF headquarters. Each agent has a set of specific *capabilities* inherent to the rank and military job classification. These *capabilities* allow the agent to perform a specific role(s) to accomplish organizational *goals* within the model. The *role* is some function played by zero, one or many agents and includes the capabilities which are inherent to particular agent. The *goals* are tasks that the organization is attempting to achieve and must be broken down into deliverable outputs and sub-goals. The model also includes *laws* or rules that constrain the assignment of agents to roles and goals. This is important during the model run to insure that the appropriate agent is constrained to play only one role or goal at a time.

For the JTF headquarters design problem, the joint mission essential tasks are considered as a set of goals to achieve. The joint mission essential tasks are defined as “the [Joint Force

Commander's] tasks most essential to their assigned or anticipated missions, with priority given to their wartime missions".[45] Each task is developed from the assigned or anticipated missions using the Universal Joint Task List to identify which joint tasks must be accomplished. The task list provides a set of operational tasks, measures and criteria for capabilities based planning in the JTF headquarters. The sub-goals have a true or false (Boolean) relation where one goal is a direct sub-goal of another.[46] Table 6 depicts an example of set of tasks (goals) and sub-tasks (sub-goals) for a G-3 Plans Cell.

Goals	***Sub-Goals***
• Plan future operations as sequels for the current Corps operation	• Plan future close, deep, and rear operations (sequels).
• Coordinate all combat, CS, and CSS activities with higher and adjacent headquarters	• Use IPB products in planning future operations.
• Synchronize future operations within the Corps during the development of plans	• Develop COAs for future operations.
• Determine concept for deep operations	• Synchronize future operations during the development of plans.
• Monitor the current situation for impact on future operations and make adjustments	• Plan tactical movements.
	• Task-organize the Corps for future operations.
	• Incorporate PIR into future operations.
	• Incorporate deception into future operations.
	• Integrate SOF into future operations, as available.
	• Incorporate reconstitution requirements into the plan.
	• Prepare conventional target lists with the FSE.
	• Integrate joint, allied, HN, and combined communications systems into future operations.
	• Coordinate combat, CS, and CSS with higher and adjacent headquarters and within the corps.
	• Review subordinate unit plans and orders for compliance with Corps orders and the commander's intent.
	• Monitor the current situation for its impact on future operations.
	• Adjust future operation plans based on current and anticipated situations.
	• Continuously plan future A^2C^2 requirements.

TABLE 6: SAMPLE JOINT STAFF TASKS FOR G-3 PLANS CELL

4.2.3 Organization State Model

The next element of the Organization Model is the organization state (O_{state}) and is defined as an instance of the organizational structure at a point in time.[47] In the research problem, the O_{state} is the initial TO&E structure for the G-3 Plan Cell of a typical U.S. Army Corps headquarters. The remaining analysis will look at the reorganization process of this staff section. The organization state includes a set of agents (A) and is defined by:

O_{state} = < A, possesses, capable, assigned, coord >

where:

possesses : A, C ⟶ [0..1]

capable : A,R ⟶ [0..1]

assigned : A,R,G ⟶ [0..1]

coord : A, A ⟶ Boolean [48]

The organization state is an instance of the organization where the agent(s), defined by their military job classification and rank or grade, coordinate through the organization via conversation and act proactively and cooperatively to accomplish goals.[49] In the state model, the agent that possesses the requisite capabilities, play that role. The capable function determines if an agent can play a particular role. The assignment function is established during the organization process where the agent is designated to play a particular role to satisfy a specific goal. The coordination function is a true or false relation and addresses when an agent is working directly with another agent. "Thus the state model defines the current state of the organization with the structure provided by the structural model."[50]

G3/PLANS CELL/MAIN

Duty Position/Paragraph Title	Grade	MOS		Required To
CHIEF	O6	02A00	3H	Plans Cell OIC, Ensures that the plans functions specified & implied in FM 100-15, chapter 4 & Appendix B are performed
NUCLEAR WEAPONS OFF	O5	13A00		Plans for the selective release of chemical and/or tactical nuclear weapons with the corps' AO
AVIATION OFFICER	O5	15B00	5A	Plan and synchronize the use of Army aviation assets to support future corps operations
PSYOP OFFICER	O5	37A00		Coordinate and evaluate psychological operations within the corps' AO on a 24 hour basis
FORCE MGMT OFFICER	O5	50A00		Reviews and analyzes planned force structure changes for their on corps operations. Coordinates the force accounting, manpower allocation, & manpower report activities throughout the corps.
OPERATIONS OFFICER	O5	57A00		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
OPERATIONS OFFICER	O4	02A00		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
PSYOP OFFICER	O4	37A00		Coordinate and evaluate psychological operations within the corps' AO on a 24 hour basis
STRATEGIC PLANS OFF	O4	59A00	3H	Plan and coordinate the corps'strategic operations on a 24-hour basis
PLANS OFFICER	O3	02A00		Plan and coordinate the corps'strategic operations on a 24-hour basis
PLANS OFFICER	O3	14B00		Plan and coordinate the corps'strategic operations on a 24-hour basis
ASST AVIATION OFFICER	O3	15B00	5A	Plan and synchronize the use of Army aviation assets to support future corps operations
SR PSYOP STAFF NCO	E8	37F50		Coordinate and evaluate psychological operations within the corps' AO on a 24 hour basis
OPERATIONS SERGEANT	E7	11B40		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
ASST OPERATIONS SGT	E7	19K4N		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
ASST OPERATIONS SGT	E6	11B30		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
OPERATIONS ASSISTANT	E5	19D20		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis
OPERATIONS ASSISTANT	E4	11B10		Perform the operations planning function specified & implied in FM 100-15, chapter 4 & Appendix B on a 24 hour basis

FIGURE 7: G3 PLANS CELL US ARMY CORPS MAIN CMD POST[51]

Figure 7 shows the staff structure for the G-3 Plans Cell with rank, military job classification, and assignment function as the organizational state model. The O_{state} model depicts a set of agents with capabilities and roles defined by duty position, military occupational specialty and rank. In the O_{state} model, not all agents possess an equal ability. The Multi-Agent Systems modeling accounts for this situation by modeling *possesses* "as a real valued function, where 0 would represent absolutely no capability to play a role while 1 indicates an excellent

capability".[52] During the organization process, a military member [agent] is assigned to play a particular duty description [role] to satisfy a specific task or goal in the model. The assign function includes a real valued score to capture how well the agent satisfies a given goal.[53] O_{state} model is one instance of the G-3 Plans Cell organization but does not account for the reorganization of the model to accomplish additional or new tasks. The addition or changes to goals or military personnel cause the model to transition to new $O_{state(1)}$. This action is addressed through the organization transition function.

4.2.4 Organization Transition Function

The organization transition function facilitates the reorganization process in Multi-Agent Systems modeling. "The organization transition function defines how the organization may transition from one organizational state to another over the lifetime of the organization."[54] The transition function accounts for the restructuring of both the organization state (O_{state}) and organization structure (O_{struct}) through the use of an initiating event. "Reorganization is initiated by a trigger event, such as capability loss, during the [model] execution of an already existing organization. When such an event occurs, the [organizational model] must determine if it still has the capabilities to satisfy [organization] goals or whether it must reorganize to do so. Reorganization is represented by $O_{state(n)} \rightarrow O_{state(n+1)}$ where n [is an element of the set] N."[55] The reorganization is a series of state transitions that occur as agent and capabilities are added or lost or goals change until the organization model reaches an acceptable state. The state transition is depicted in Figure 6 with Ø representing a set of capabilities or agents which cause the transition. The transition function includes a set of finite start states and a set of reachable states.

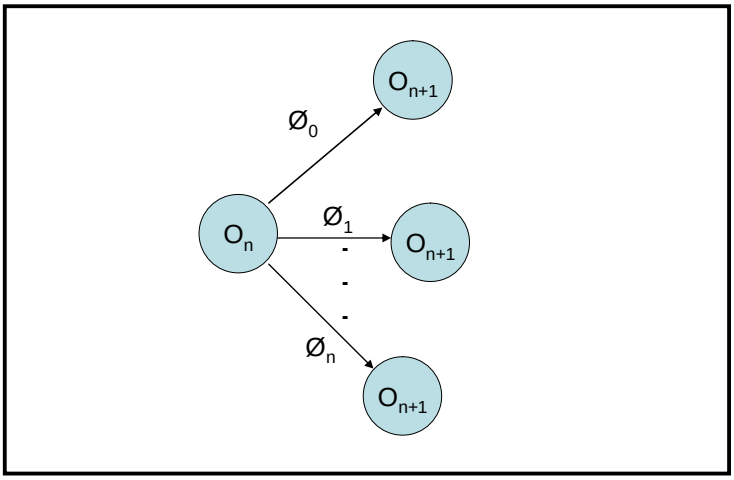

FIGURE 8: STATE TRANSITION[56]

The organization transition model is expressed as:

$$O_{transition} = (O, \Phi, \delta, S_n, S_{optimal}, S_{possible}, S_{final})$$[57]

The basic transition is defined as a product of the *O*, Φ and S resulting in a set of reachable organization states:

$$\delta : O \; x \; \Phi \; x \; S \rightarrow S$$[58]

The finite transition eventually results in a final state as is defined as

$$\delta(O_i, \Phi, S) \; |-^* \; S_{final}$$[59]

The outcome of the finite transition organization possibly is a successful organization capable of satisfying the organizational goals and thus solving the transition problem. Deloach and Matson have developed a useful transition theory for complex multi-agent systems. The definitions of transition and reorganization theory support the requirement of multi-agent organizations to be adaptable, re-configurable and possess the capability to survive.[60] For the JTF headquarters reorganization problem, this modeling theory represents an efficient tool to

analyze small organizational frameworks to solve problems that require self-organization and adaptation.

CHAPTER 5: CONCLUSIONS

This research document looks at the organizational design requirements for Service headquarters to operate as JTF headquarters. Specifically, the research develops and analyzes three alternatives for organizing the headquarters and investigates the use of modeling and simulation as a method to solve the design problem.

5.1 Summary and Contributions of Work

One contribution of this work to update the body of knowledge on Department of Defense and NATO initiatives that have resulted in significant advancements to Joint Command and Control. Notable advancements include:

1. the Standing Joint Task Force Headquarters;
2. the 2003 NATO decision to implement a 2-star level Deployable JTF headquarters;
3. the Standing Joint Force Headquarters Core Element; and the
4. QDR 06 directive to transform 3-star and selected 2-Star Service headquarters into JTF capable headquarters.

Collectively, these initiatives have resulted in significant improvement to joint command and control headquarters capabilities.

A second major contribution of this work is the formation of three alternatives to organization a JTF capable headquarters. The analysis included a multi-criteria decision making technique that combines both qualitative and quantitative factors in the evaluation of alternatives. The Analytic Hierarchy Process provides a methodology that may be used by the Services, Combatant Commands and Joint Forces Command to solve current and future organizational design problems.

A third major contribution of this research is the investigation of modeling and simulation as a method to analyze options for reorganizing Service headquarters for specific JTF missions.

Multi-Agent Systems modeling provides a theoretical method to solve the reorganization problem for a Service headquarters required to perform as a JTF headquarters. The methodology is most useful to analyze limited aspects of the organization such a specific JTF staff section. The modeling output would need to be further analyzed against the Joint Manpower Exchange Program to provide the requisite joint manpower for each type of 3-star Service headquarters.

5.2 FUTURE WORK

This work has concentrated mainly on the formulation of decision alternatives for reorganizing Service headquarters, and the investigation of modeling and simulation to solve problems that require self-organization and adaptation. This research did not investigate if it is feasible to assign JTF missions that include major ground combat to US Navy Numbered Fleet Headquarters or US Air Force Numbered Headquarters. The research concludes with a list of future work.

1. Complete analysis to determine if all 3-star Service headquarters must provide full-spectrum JTF capabilities.
2. Conduct feasibility and affordability analysis on the three options to reorganize the 3-star Service headquarters paying particular attention to the manpower limitations as well as the targeted capabilities for each type of Service headquarters.
3. Continue to investigate modeling and simulation as an efficient tool to analyze organizational frameworks that require reorganization.

Finally, Joint Forces Command should remain as the coordinating headquarters with supporting strategic guidance from the Defense Department. The successful transformation of Service headquarters to JTF capable headquarters should not be left to the purview of each Service.

Appendix A

ANALYTIC HIERARCHY PROCESS

Pair-wise comparison data for the Analytic Hierarchy Process, discussed in Chapter 3, is used in the analysis of alternatives and development of recommendations. A pair-wise comparison of criteria generates a table of relational data for comparing alternatives. The Analytic Hierarchy Process uses the relational scale of real numbers from 1 to 9 to systematically assign preferences. Using this scale, a pair-wise comparison is conducted at each level relative to each element at the next higher level in the hierarchy to determine the relative priority.

The next step in the Analytic Hierarchy Process is to compute a composite ranking of all criteria based on the pair-wise comparison results. The eigenvector methodology generates an estimated relative weight for each criterion. In calculating the estimated relative weights for the criteria, all fractions are converted to decimals to the fourth place. Next, each value in the matrix is squared and each row is summed. The resultant eigenvector is determined by normalizing the sum of each row to give a relative weight, or ranking, for each criterion. The eigenvector scores reflect the importance of a given criterion, with the largest score as the most important criterion. The complete set of results for the Analytic Hierarchy Process is given below.

Pair-wise comparison of Criteria:

Criteria	Affordability	Multi-functionality	Scalability	Deployability	Acceptability
Affordability	1	1	5	3	3
Multi-functionality	1	1	5	3	3
Scalability	1/5	1/5	1	1/5	1/5
Deployability	1/3	1/3	5	1	1
Acceptability	1/3	1/3	5	1	1

Relative weights for Criteria:

Criteria	Afford.	Multi-.	Scalab.	Deploy.	Accept.	Sum	Eigenvector
Affordability	5.0000	5.0000	45.0000	13.0000	13.0000	81.0000	0.3402
Multi-functionality	5.0000	5.0000	45.0000	13.0000	13.0000	81.0000	0.3402
Scalability	0.7333	0.7333	5.0000	1.8000	1.8000	10.0667	0.0423
Deployability	2.3333	2.3333	18.3333	5.0000	5.0000	33.0000	0.1386
Acceptability	2.3333	2.3333	18.3333	5.0000	5.0000	33.0000	0.1386
						238.0667	1.0000

Pair-wise comparison of alternatives to Affordability:

Affordability	Alternative 1	Alternative 2	Alternative 3
Alternative 1	1	1/2	1/6
Alternative 2	2	1	1/4
Alternative 3	6	4	1

Relative weights of alternatives based on Affordability:

Affordability	ALT 1	ALT 2	ALT 3	Sum	Eigenvector
ALT 1	3.0002	1.6668	0.4584	5.1254	0.1058
ALT 2	5.5000	3.0000	0.8334	9.3334	0.1926
ALT 3	20.0000	11.0000	3.0002	34.0002	0.7016
				48.4590	1.0000

Pair-wise comparison of alternatives to Multi-functionality:

Multi-functionality	Alternative 1	Alternative 2	Alternative 3
Alternative 1	1	5	9
Alternative 2	1/5	1	5
Alternative 3	1/9	1/5	1

Relative weights of alternatives based on Multi-functionality:

Multi-functionality	ALT 1	ALT 2	ALT 3	Sum	Eigenvector
ALT 1	3.0000	11.8000	43.0000	57.8000	0.7432
ALT 2	0.9556	3.0000	11.8000	15.7556	0.2026
ALT 3	0.2622	0.9556	3.0000	4.2178	0.0542
				77.7733	1.0000

Pair-wise comparison of alternatives to Scalability:

Scalability	Alternative 1	Alternative 2	Alternative 3
Alternative 1	1	3	7
Alternative 2	1/3	1	5
Alternative 3	1/7	1/5	1

Relative weights of alternatives based on Scalability:

Scalability	ALT 1	ALT 2	ALT 3	Sum	Eigenvector
ALT 1	3.0000	7.4000	29.0000	39.4000	0.6535
ALT 2	1.3810	3.0000	12.3333	16.7143	0.2772
ALT 3	0.3524	0.8286	3.0000	4.1810	0.0693
				60.2952	1.0000

Pair-wise comparison of alternatives to Deployability:

Deployability	Alternative 1	Alternative 2	Alternative 3
Alternative 1	1	1/5	1
Alternative 2	5	1	3
Alternative 3	1	1/3	1

Relative weights of alternatives based on Deployability:

Deployability	ALT 1	ALT 2	ALT 3	Sum	Eigenvector
ALT 1	3.0000	0.7333	2.6000	6.3333	0.1550
ALT 2	13.0000	2.9999	11.0000	26.9999	0.6607
ALT 3	3.6665	0.8666	2.9999	7.5330	0.1843
				40.8662	1.0000

Pair-wise comparison of alternatives to Acceptability:

Acceptability	Alternative 1	Alternative 2	Alternative 3
Alternative 1	1	1	5
Alternative 2	1	1	5
Alternative 3	1/5	1/5	1

Relative weights of alternatives based on Acceptability:

Acceptability	ALT 1	ALT 2	ALT 3	Sum	Eigenvector
ALT 1	3.0000	3.0000	15.0000	21.0000	0.4545
ALT 2	3.0000	3.0000	15.0000	21.0000	0.4545
ALT 3	0.6000	0.6000	3.0000	4.2000	0.0909
				46.2000	1.0000

Overall ranking of alternatives using the Analytic Hierarchy Process

Eigenvectors	Affordability	Multi-functionality	Scalability	Deployability	Acceptability	
Criteria	0.3402	0.3402	0.0423	0.1386	0.1386	ALT Ranking
ALT 1	0.1058	0.7432	0.6535	0.1550	0.4545	0.4010
ALT 2	0.1926	0.2026	0.2772	0.6607	0.4545	0.3008
ALT 3	0.7016	0.0542	0.0693	0.1843	0.0909	0.2983

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